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Evaluating the Effects of Different Frequencies on Retention

by

Bethany O. Greene

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Applied Behavior Analysis
Department of Child and Family Studies
College of Behavioral and Community Sciences
University of South Florida

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DEDICATION

This thesis is dedicated to my wonderful parents who have guided and supported me throughout my entire life. I could not have completed this research without your constant support and words of wisdom. Throughout the ups and downs of this process you both always knew what to say. Thanks for always believing in me.

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ABSTRACT

Traditional teaching methods use accuracy-only criterion when teaching students a specific skill, but more and more students are being left behind in classrooms because they are not mastering the skill. Using fluency, a combination of speed and accuracy, as a mastery criterion has shown to improve both retention and mastery. Previous research suggested that frequency scores closer to the predicted frequency aim produced greater retention. It is unclear at what frequency aim a decay in retention begins to occur. The purpose of the present study was to examine the differential effects of retention on preschool participants' reading first grade Dolch sight words once the skill had been strengthened to 3 frequencies (i.e., 15 correct words/min, which is 25% of the accepted fluency aim, 30 correct words/min, which is 50% of the accepted fluency aim, and 60 correct words/min, which is 100% of the accepted fluency aim) using fluency training and the Precision Teaching method. Three preschool age participants were assessed for retention 2 weeks and 6 weeks after reaching criterion. All participants maintained teaching frequencies of correct responding 2 weeks after reaching mastery for all 3 frequency aims. Six weeks after teaching, 1 out of 3 participants showed retention for the 15 correct words per min criterion, all participants showed retention for the 30 correct words per min criterion, and all participants showed a decay in retention of correct responding for the 60 correct words per min criterion. Limitations and future research were discussed.

CHAPTER ONE:

INTRODUCTION

Children in both general and special education are failing to master basic skills by the third grade (Johnson & Street, 2013). Despite emerging evidence of failure to thrive in the core curriculum, students are not given alternative instructions; rather, they are continuously given the same instruction or moved on in the curriculum despite not mastering the skills (Johnson & Street, 2013).

The President's Commission on Education emphasized this point by saying that students are failing to progress not because of a learning disability, but rather students are not progressing because of the inappropriate and ineffective instruction on the part of the teachers (Yell & Drasgow, 2007). Johnson and Street (2013) go on to note that often evidence-based practices are set aside and curricula aligned with the teachers' philosophical views are used regardless of the impact on the students. Students need to be taught using procedures and strategies that are research-based and have sound evidence to show their effectiveness. Johnson and Street (2013) described research-based interventions as interventions that have been proven effective in bringing similar students to mastery in an acceptable period of time.

Teachers using traditional teaching methods look to accuracy as the skill mastery criterion (Hartnedy et al., 2005). Once students obtain accuracy of 80% or above, teachers move the student to the next skill. Using accuracy as a measure of learning only describes

improvements in quality and reveals nothing about quantity (West, Young, & Spooner, 1995). In addition to accuracy, fluency provides a more accurate measure of skill mastery as evidenced by retention, endurance, and application outcomes.

Fluency is the combination of accuracy and speed. A person is said to be fluent in a skill when a response occurs without hesitation. Fluency can be understood in the following example: Ms. Gibson has two students taking a basic math test. Lauren completes 10 problems in 30 min with 100% accuracy, but Samantha completes 10 problems in 10 min with 100% accuracy. Both students meet the accuracy criterion of 100%; but, if Samantha always finishes the work more quickly than Lauren, a difference in mastery between the two learners can be identified. It is only when speed, or frequency of responding, is incorporated into the evaluation that a distinction between the two learners is evident. Speed plus accuracy is a more sensitive measure of mastery than accuracy alone (Berens, Boyce, Berens, Doney, & Kenzer, 2003). Fluency is asserted to be the better metric of mastery because of the outcomes associated with it. Three critical outcomes of fluency include retention (i.e., the ability to perform the behavior after substantial periods of no practice), endurance (i.e., the ability to perform a behavior over prolonged amounts of time), and application (i.e., the ability to apply the skills to known and new situations) (Binder, 1996).

A number of studies have provided evidence for using fluency as the indication of mastery (Berens et al., 2003; Bucklin, Dickinson, & Brethower, 2000; Singer-Dudek & Greer, 2005). Bucklin, Dickinson, and Brethower (2000) specifically examined retention by comparing accuracy criterion to a fluency criterion with adults. Participants learned associations between Hebrew symbols and nonsense syllables, and nonsense syllables and Arabic numerals. The study used a between groups design in which one group was trained using the accuracy mastery training and the other group received fluency mastery training. Both groups completed the

training with 100% accuracy, but the fluency trainees emitted on average 8.3 more responses correct per min than the accuracy trainees. After the associations were trained, both groups were tested on the original tasks following four months without any practice on the skill. Fluency trainees had less deterioration in the skill and better accuracy on the retention checks when compared to accuracy mastery trainees. Overall, this research showed that the fluency trainees performed the skill more proficiently on the retention checks than the accuracy only trainees.

Research on fluency and its outcomes derive from the literature on Precision Teaching. Precision Teaching (PT) has been effectively applied to complex math skills (Mayfield & Chase, 2002), basic reading skills (Hughes, Beverley, & Whitehead, 2007; Kubina, Amato, Schwilk, & Therrien, 2008), spelling (Noland, McLaughlin, & Sweeny, 1994; Shirley & Pennypacker, 1994), writing (Spaulding, Haertel, Seevers, & Cooper, 1995), and reading comprehension (Polk, & Miller, 1994), with typically developing adults (Noland, McLaughlin, & Sweeny, 1994; Spangler & Hankins, 1975), and children with developmental disabilities (Kubina, Morrison, & Lee, 2002; Weiss, Fabrizio, & Bamond, 2008).

PT, a data-based measurement system, is the subset of behavior analysis that emphasizes fluency of a skill as the mastery criterion as opposed to accuracy alone (Kubina & Yurich, 2012). In PT, fluency is represented as a frequency aim, or a performance standard, which is depicted as a number of correct responses emitted in a given amount of time. For example, the predicted frequency aim for reading an eighth grade reading passage is 200 correct words per min for students in eighth grade (Hasbrouck & Tindal, 1992).

Predicted frequency aims are determined by sampling frequency ranges from a pool of individuals that are said to be fluent in the skill (Binder, 1996). These frequency aims are “predicted” because it is expected an individual who meets the predicted frequency aim will be

fluent once frequencies reach that particular aim. Once a behavior or skill reaches fluency, empirically validated outcomes including retention, endurance, and application occur (Kubina & Morrison, 2000). Fluency can only be determined by testing for the outcomes. In other words, a person is fluent in a skill when they can perform the skill after a period of time without practice, perform the skill over prolonged amounts of time, and apply the skill to known and new situations.

Fluency may occur at different frequency aims for each individual, and for this reason Haughton (1972) suggested that aims should be “individualized to suit the individual student” (p. 22). Individual frequency aims may be set empirically through retention, endurance, and application testing (Binder, 1996). For example, although the predicted reading frequency aim is 200 words per min, the child who reads 190 words per min and also demonstrates retention, endurance, and application is fluent. In this case, 190 words per min may now be used as the frequency aim for this individual.

Not only can frequency aims be individualized for each learner, but Binder asserted that there may be a different frequency aim to produce each fluency outcome (i.e., retention, endurance, application) (Binder, 1996). The results of Singer-Dudek and Greer (2005) support Binder’s theory that different fluency aims produce different outcomes. The researchers studied the outcomes related to application and retention more precisely. They compared two training methods on the performance of component math skills (i.e., single-digit multiplication facts and single-digit addition facts). Component skills were defined as simple skills that are needed to learn and understand the more complex composite skills, such as prerequisites. Four participants were trained using accuracy as the mastery criterion while four different participants were trained using fluency as the mastery criterion. Mastery for the component skills in the accuracy

only groups was defined as 100% accuracy in writing answers to the math problems. The fluency mastery group had to write the answer to simple component math questions with 100% accuracy at 100 problems per min. Results indicated that both groups met their respective criterion and completed the same number of component math problems accurately, but the fluency-mastery group completed the math problems at higher speeds. The participants were then taught more complex composite skills (i.e., multiplication of two-digit numbers by two-digit numbers) using the same mastery criterion previously used. Composite skills are higher-order, more complex skills, which are created from component skills. The participants needed to use the component skills previously taught in order to successfully complete the composite skills. Mastery of composite skills demonstrates application of component skills.

Results showed that both groups learned the composite skill at a similar speed regardless of the mastery criterion used to learn the component math skill. In other words, both the accuracy and the fluency groups could apply the component skill to the composite skill or demonstrated application. However, there was a distinction between the groups with respect to their composite skill accuracy on retention. The accuracy group's retention data produced scores ranging from 17-83% correct, whereas the mastery participants yielded scores ranging from 83-100% correct. The frequencies at which participants performed the retention checks were not reported. The researchers concluded that achieving fluency in a component skill could aid in better retention of composite skills thus leading to less time re-teaching skills (Singer-Dudek & Greer, 2005).

Bucklin et al. (2000) also sought to investigate the differential effects of accuracy and fluency as the mastery criterion on the application and retention of more complex skills. During a stimulus equivalence task, participants were taught a simple component skill using either accuracy or fluency as the mastery criterion. In order to learn the higher-level composite skill,

the participants had to utilize the previous knowledge of the lower level component skill. Results indicated that when compared to accuracy participants, fluency participants had increased retention of accurate responding for both component and composite skills. After 4 weeks, fluency participants averaged 76.3% items correct per min on the composite skill whereas accuracy participants averaged only 15.8% items correct per min. Similar to Singer-Dudek and Greer (2005), these data suggested that fluency training can aid in the acquisition of higher level skills as well as yield greater retention and therefore better mastery of the skill.

While these studies suggest that different frequency aims may produce different outcomes of fluent performance, few studies have investigated using different frequency aims to produce retention specifically. Berens et al. (2003) studied the retention of math flash cards trained to different frequency aims after a one-month break between training and retention tests. Five participants were taught basic math skills using math flash cards. Researchers found participants that emitted response frequencies closer to the predicted fluency range on a math skill prior to the end of the training period performed better on the fluency retention probe. They also found that 4 out of 5 participants who had a steeper acceleration (i.e., higher acquisition rate) during training showed better retention when compared to the students that progressed more slowly. Results further suggested that additional practice opportunities did not enhance skill retention unless response frequencies were close to the predicted fluency range for that particular skill.

Binder (1996) suggested a need to investigate the effect various frequencies have on retention in order to determine if response frequencies close to the predicted fluency range or frequencies lower than the predicted fluency range would produce retention. Kubina et al. (2008) sought to extend the research on retention following Binder's suggestion by examining the

effects a high-frequency aim had on retention compared to a low-fluency aim. They selected the frequency aims based on the predicted frequency aim of 162 correct words per min (Hasbrouk & Tindal, 1992). The high frequency aim was 38 words per min faster than the predicted frequency aim (i.e., 200 correct words per min) and the low frequency aim was 39 words per min slower than the predicted frequency aim (i.e., 123 correct words per min). Three students with learning disabilities read two reading passages to the different predicted frequency aims. Frequency for one story was built to the frequency aim of 123 correct words per min and the other story was built to the frequency aim of 200 correct words per min. Participants took 2-3 times more practice opportunities to obtain the frequency of 200 correct words per min when compared to the length of time it took participants to read the 123 correct words per min. For example, one participant took 25 calendar days to obtain the frequency of 202 correct words per min, whereas it took the same participant 7 days to reach 132 correct words per min frequency.

Retention results indicated that the deceleration of correct words per min was the same for both passages. In other words, the percentage of decay in retention frequencies of the 200 correct words per min passage was the same as the retention frequencies of the 123 correct words per min passage. These results suggest that lower frequency aims could also produce retention. As suggested in Berens et al. (2003), the Kubina et al. (2008) study found that more practice opportunities at high frequencies did not equate to better retention, meaning that even though the participants practiced the 200 correct words per min passage more, retention was not significantly better for that passage.

Some limitations of the Kubina et al. (2008) study may prohibit assumptions about the effect different frequency aims have on retention. For example, the starting frequency was not controlled for in the research study. Specifically, each student began the study reading at a

different frequency, which subsequently could have influenced each participant's number of practice opportunities. Had the participants started the study at the same frequency level, the deterioration of retention could be more precisely compared with respect to practice opportunities.

Given the findings of Berens et al. (2003) and Kubina et al. (2008), there seems to be an opportunity to clarify whether performance at a predicted frequency aim produces greater outcomes on retention probes or if individuals will continue to be accurate and perform at the same speed using various frequency levels below the predicted fluency aim. While the findings of these two studies suggested that frequency scores closer to the predicted frequency aim produced greater retention, it is unclear at what frequency aim a decay in retention begins to occur. In other words, will building a skill to 50% of the predicted fluency aim continue to produce skill retention or will there be a decay in retention?

The current study aimed to extend the research on retention and fluency by addressing the issues related to the Kubina et al. (2008) study. The purpose of this study was to examine the retention of reading sight words with typically developing Pre-K students once the skills had been strengthened to three frequencies using fluency training and the PT method. This study extends the literature by evaluating the effects on retention of frequencies below the predicted frequency aim.

The study addressed the following research questions:

1. What is the extent of retention when sight words are trained to a frequency 25% of the accepted frequency aim?
2. What is the extent of retention when sight words are trained to a frequency 50% of the accepted frequency aim?

3. What is the extent of retention when sight words are trained to a frequency 100% of the accepted frequency aim?
4. Is there a difference in retention accuracy and fluency among the three frequencies after 2 and 6 weeks following learning?

CHAPTER TWO:

METHOD

Setting

The study took place at a university preschool in a large metropolitan area. Students aged 2 to 5-years-old were enrolled. The setting was a university-based preschool that principally catered to students, teachers, and staff of the university. However, a few students enrolled were from the surrounding community. The families represented a varied social and economic group. The school had a population of 74 students with 42 students enrolled in two pre-kindergarten (Pre-K) classrooms. Each Pre-K classroom had one teaching assistant and one lead teacher. The school utilized the Project Approach as a framework for addressing the state early learning standard. Sight words were not taught in the classrooms.

Individualized sessions with each participant were conducted in a room with minimal distractions. The room had a table with two chairs seated across from each other. Only the materials in use during the session were on the table; all other materials were placed under the table. One participant, Scarlett, left the school after reaching the retention phase of the study and retention checks were conducted in her home in a quiet room with a table and chairs.

Participants

Although previous studies (Kubina et al., 2008) used reading passages and older students, preschool students were chosen for this study to control for previous knowledge of written words and to minimize the opportunity for them to learn the study words outside of the experimental environment. Preschool students are familiar with letter names, but are not exposed to sight words in the classroom, making it more likely that the participants had no previous exposure to the words and participants would not be learning the words in the classroom.

Teacher

Two teachers in two Pre-K classrooms were asked to participate in the study. They were initially provided with a detailed description of the study and asked to nominate students that had: a) the ability to recognize English letter names, b) inability to read sight words, c) no history of severe problem behaviors (e.g., aggression, property destruction), and d) no developmental or learning disability. Only one teacher identified students who met all of the criteria. This teacher participated in the study. She was a female that had been teaching in a Pre-K classroom for 6 years. The teacher's involvement included nomination of participants, allowing participants to leave the classroom for teaching and assessment, and completing a social validity checklist.

Students

Four students participated in the study based on teacher nomination and scores on the selection assessment that was administered to assess current knowledge of letters and sight words. Three of the four students were experimental participants. In order to control for practice opportunities and amount of exposure to the words, one of the four students was identified as a

control or yoked participant. The control participant was chosen randomly among the four students and was yoked with a randomly selected experimental participant (Singer-Dudek & Greer, 2005). All student participants were chosen using the same selection procedure. Teachers consented to participate in the study and nominated students who met the selection criteria listed above. Parents of the nominated students were given a letter with a detailed description of the study and agreed to let their child participate. Participants were chosen from a classroom once the teacher and parent had given informed consent. The researcher asked the students to verbally assent to participate. Finally, student's knowledge of letters and words were assessed.

All four participants were entering kindergarten 2 months after the conclusion of the study. The four participants consisted of one female and three males who attended the Pre-K classroom. Scarlett was a 5-year-old 3-month female, Rhett was a 4-year-old 10-month male, and Frank was a 5-year-old 3-month male. Charles, the control participant, was a 4-year-old 6-month male. All participants were proficient in English.

Participant Assessment Procedures

Upon teacher nomination and informed consent, the researcher conducted an assessment in order to determine the students' skill level. Students chosen for the study: 1) had the ability to sit in a chair and attend to an activity for at least 5 mins, 2) achieved 80% accuracy identifying letters in the English alphabet, and 3) achieved 0% accuracy reading first-grade Dolch sight words. Identifying letters is a pre-requisite for reading sight words and was a skill needed for participants to distinguish differences between two words. Starting participants with 0% accuracy reading sight words eliminated prior knowledge as a confounding factor.

Assessment materials. Materials for the assessment included two worksheets: a) a letter worksheet and b) a sight words worksheet. The letter name worksheet consisted of all 26 English letters in random order with each letter represented once (see Appendix A). The sight word worksheet consisted of 23 first-grade Dolch words (see Appendix B). First-grade Dolch words are known as “tool” words that are used in all writing that a student should know by sight in first grade (Dolch, 1936). These words were chosen to reduce the probability of participants sounding out the word. Further, the level of words was chosen to control for the participants’ exposure to the word. The assessment verified that these participants had not been exposed to these words before the study began. Additional materials included a digital timer, a pencil, a data sheet, and standard celeration charts (SCC) (i.e., timings per min chart and daily per min chart).

Assessment procedure. The primary researcher served as the instructor and conducted the assessment while sitting across from the student in a room with minimal distractions. The researcher first modeled the desired responses. Following the model, the student engaged in a total of four timings. The first two timings were conducted as duration timings of the student reading the letter name on the worksheet. The second two timings were also conducted as duration timings of the student reading all first-grade Dolch sight words. The duration timings provided accuracy data that guided the researcher in determining whether the participant met the inclusion criteria. All the students achieved over 80% in letter name recognition accuracy with scores ranging from 84%-92% correct. Rhett and Charles obtained a score of 84% accuracy in letter recognition, and Scarlett and Frank obtained a score of 92% accuracy in letter recognition. None of the students recognized the first-grade Dolch words with each student obtaining a score of 0% accuracy.

Specifically, the four timings proceeded as follows. The researcher began the timer once the student emitted the first letter/word and ended the timer after the last response was given. This is known as a duration timing. Responses were classified by specific input and output behaviors called learning channels. In this instance, the participant saw the word “open” and said the word “open.” Therefore, the participant used the “see/say” learning channel. If the student did not know a word, the researcher prompted the student to say a response functionally similar to “I don’t know” (e.g., skip, no). General praise (e.g., good job, thank you) was given for participation; however, no specific praise or feedback was given contingent upon correct or incorrect responding.

Data Collection

The dependent variable in this study was the rate of correct and incorrect responding to sight words (i.e., frequency). Student responses were considered correct if they included the correct pronunciation of the word. Unknown words, skipped words, incorrect pronunciation, and lack of a response within 3 s were defined as incorrect responses to sight words. Unknown words were those that the student emitted a response functionally equivalent to “I don’t know.” Researchers recorded responses using rate (i.e., frequency over time). The dependent variable was measured in each phase of the study.

Each timing in the baseline and retention phases was 15 s in length. Timings in the teaching phase were 30 s in length. Timing lengths were determined through clinical experience with the skill of word recognition and age of the user included in the study (K. Milyko, personal communication, May 4, 2015). Each session was recorded via a video and audio recorder. The researcher placed the video and audio recorder in an un-obtrusive area beside the child, to ensure

each flash card was visible in the recording. The researcher recorded the frequency of correct and incorrect responses using the video and audio recordings of each session. Data are displayed on a Standard Celeration Chart (SCC). The SCC was used for an analysis of the overall celeration of the learner.

Interobserver Agreement

A research assistant also observed sessions via video and audio recording to assess IOA. The researcher trained research assistants during two data collection sessions to ensure IOA percentages met 100% agreement. Data were collected on the correct and incorrect responses during each 15-s timing (See Appendix C). An agreement was marked if both observers marked the response as correct or incorrect, and a disagreement was marked if correct and incorrect responses were marked differently. The percentage of IOA was determined by dividing the number of agreements (i.e., responses scored identically) by the total number of responses and then multiplying the result by 100% (Kazdin, 2011). IOA was assessed for 33.3% of sessions during the baseline, 39.2% of sessions during the teaching phase, and 40% of sessions during the retention phase with 100% IOA agreement for each phase

Procedural Integrity

This study addressed procedural integrity by having a research assistant watch videos of sessions from each phase of the study (Umbreit, Ferro, Liaupsin, & Lane, 2007). While watching the videos, the research assistant completed a checklist to ensure that the researcher was implementing the study correctly (see Appendix D and Appendix E). A yes was circled if the procedural element was implemented correctly. At the end of the session, yes responses were

tallied and calculated as a percent of the total. The checklist included five items that identified specific steps completed by the researcher during the baseline and retention phases and 19 items for the teaching phase. Procedural integrity was collected during 33.3% of sessions during baseline, 39.2% of sessions during the teaching phase, and 40% of sessions in the retention phase. The researcher had 100% fidelity in all sessions across each phase of the study.

Experimental Design and Procedures

The study was conducted using an adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985). This design allowed for comparison across all three frequencies. All participants were exposed to the baseline, teaching, and retention phases. Four sets of sight words were alternated within each session. Frequencies were identified based on the accepted predicted fluency aim for Pre-K students reading sight words, which is 60 correct words per min. Each frequency used in the study is a percentage of the accepted fluency aim. The three aims were 15 correct words per min, which is 25% of the accepted fluency aim; 30 correct words per min, which is 50% of the accepted fluency aim; and 60 correct words per min, which is 100% of the accepted fluency aim.

Once a participant met the frequency criterion for a set of words, retention was assessed for that set. Each set was identified by a different color background on the flash cards. Flash cards sets were a different color in order to increase stimulus control between the different sets and decrease the possibility of interactions among the sets.

The study consisted of three phases for all participants: baseline, teaching, and retention. Four sets of sight words were used. The researcher taught each participant three sets to a

different frequency: 15/min, 30/min, and 60/min. The fourth set of sight words was used as a non-instructional set to control for possible carry-over learning between sets.

Experimental Materials

Materials needed for the research sessions included a three ring binder for each participant, sheet protectors, a digital timer, SCC (timings, daily, weekly, and computerized daily and weekly charts), flash cards, and a video and audio recorder. Upon completion of the session, small tangible items (i.e., stickers) were available to use as reinforcers.

Words to be used on the flash cards were identified during the assessment completed in the selection phase. Out of 23 possible first-grade Dolch words, 16 words were chosen based on the criterion that none of the participants recognize them. Each participant had 4 sets of 24 flash cards. Within each set of flash cards, four different sight words were repeated six times totaling 24 flash cards. The words represented in each sight word set are listed in Table 1.

The sight word sets were counterbalanced across participant. Sight word sets were randomly presented as listed in Table 2.

Table 1

Words in Sight Word Sets

Set A	Set B	Set C	Set D
thank	were	know	every
any	think	over	from
when	an	her	of
some	once	then	live

Table 2

Counterbalanced Sight Word Sets

Participant	15 correct words per min Sight word list	30 correct words per min Sight word list	60 correct words per min Sight word list	Control sight word list
Scarlett	Set C	Set B	Set A	Set D
Rhett	Set B	Set A	Set C	Set D
Frank	Set A	Set C	Set B	Set D
Charles	Set A	Set C	Set B	Set D

Baseline

Procedures in this phase were the same for the three experimental participants. Baseline data were collected for the three experimental sets and the control set (i.e., set D) of sight words. All sets were presented in the same day during baseline sessions. Once seated in the room across from the researcher, the participants were informed they were going to read words as fast as they could for 15 s. The researcher demonstrated the procedure by modeling using flash cards with months of the year written on them. Modeling the procedure with words unrelated to the study ensured that participants were not learning the words during the model. Flash cards were shuffled before each timing to ensure the words were being presented randomly. Following the model, a 15-s see/say timing began once the participant had emitted the first sound. During the timing, the flash cards were piled in the researcher's hands with only one word exposed at a time. Once the participant emitted a word, the researcher would flip the flash card to reveal the second word. The timing ended upon completion of the 15 s as indicated by the timer beeping. Once the timing was complete, general praise and a small tangible reinforcer (i.e., sticker) was given for participation. No specific reinforcement or feedback was given for speed or accuracy during the session. Baseline sessions for each set of flash cards occurred on consecutive days

until stability was reached. Researchers charted the data on individual SCCs for each set of sight words.

The control participant, Charles, had the opportunity to respond to the same number of words and the same set of words at each aim as Frank. For example, if Frank was exposed to one see/say timing yielding exposure to 12 words, then the control participant (i.e., Charles) had the opportunity to respond to 12 words as well. Charles was given as much time as needed to respond to the words. General praise was given for participation only.

Teaching

The teaching procedures were the same across participants and sight word sets. Sessions were conducted on average 3-4 days a week and lasted no longer than 20 min. The number of session days was determined through clinical experience (K. Milyko, personal communication, May 4, 2015). There were four total timings per session: a see/say timing, followed by two hear+see/say timings, ending in another see/say timing. Only the control sight word set was different in that it wasn't taught. The only timing used for this set of sight words was the first see/say timing. Charles was provided with the same number of flash cards as Frank, and he was given the opportunity to respond to the same number of sight words as the experimental participant but was not timed.

During the see/say timing, the researcher set a timer for 15 s and the participant looked at each word and said as many of the words in the specific set as possible within the time limit. The flash cards were shuffled and the timer began when the participant emitted the first sound. During the timing, the flash cards were piled in the researcher's hands with only one word exposed at a time. Once the participant emitted a word, the researcher flipped the card to reveal

the second word. The timing ended upon completion of the 15 s as indicated by the timer beeping. Once the timing was complete, general praise was given for participation. The see/say timing functioned as a probe to identify the frequency at which they were performing and whether they had met the frequency criterion for that set of words. No specific reinforcement or feedback was given for speed or accuracy during or after the timing.

Following the first see/say timing, the researcher shuffled the flash cards for the hear+see/say timing. This timing, and specific learning channel, was selected for the purpose of building accuracy for the see/say timings. In the hear+see/say timing, the researcher said the word immediately upon presentation of the sight word to the participant and the participant was given the opportunity to repeat the said word. For example, the researcher flipped over the first flash card of the set. If the first word on the flashcard was “my”, the researcher said “my” and then the participant said “my” as well. If the participant repeated the same word as the researcher, then that response was defined as “correct.” If the participant repeated a word other than the one emitted by the researcher, that response was defined as an “error.” Other responses that were classified as errors were no response within 3s or the participant saying a response functionally similar to “I don’t know.” This exchange lasted throughout the entire 30-s timing and was repeated for the second hear+see/say timing. Reinforcement was given for correct responding and after error correction. Errors were corrected after the timing ended. The amount of reinforcement given was recorded during these timings to control for reinforcement effects. The last timing of the session consisted of another 15-s see/say timing. During this phase, participants were given praise (i.e., great speed, nice job, perfect) as reinforcement for correct responding and increasing frequencies after the timing. Reinforcement for both teaching and the last timing was given on a percentile schedule where the student had to perform 30% better than

the last 10 frequencies. The amount of reinforcement given during these timings was noted by the researcher on the SCC. The teaching phase for a set of sight words was complete once the participant had reached the mastery criterion for two first see/say timings.

Charles engaged in the same procedures as the experimental participants. Four trials were conducted with Charles. The first trial was a see/say, the next two trials were hear+see/say, and the last trial was a see/say. Charles received the same amount of practice as the experimental participant. For example, if the experimental participant (i.e., Frank) was exposed to two hear+see/say timings yielding exposure to 12 words total, then Charles had the opportunity to respond to 12 words using the hear+see/say learning channel. Charles was given as much time as necessary to complete the words. Reinforcement was only given contingent on the performance of the experimental participant. Regardless of Charles' performance, if Frank received reinforcement for the trial then Charles did as well.

Retention

Upon reaching the identified mastery criterion (i.e., 25%, 50% or 100% of aim), the ~~same~~ set of sight words used in the teaching phase entered the retention phase of the study and participants were no longer exposed to the words in the set. Two and 6 weeks after reaching mastery on a set, retention probes were conducted. One 15-s see/say timing was conducted in which the researcher asked the participant to say the words on the flash cards as fast as they could. The flash cards were shuffled and piled in the researchers hands with only one word exposed at a time. The timer began once the participant had emitted the first sound. Once the participant emitted a word, the researcher flipped the card to reveal the second word. The timing ended upon completion of the 15 s as indicated by the timer beeping. Once the timing was

complete, general praise and a small tangible reinforcer (i.e., sticker) was given for participation. No specific reinforcement or feedback was given for speed or accuracy during the session. During the retention phase, the control sight word set was probed using the same procedures as those used for the experimental sets once the participant had reached mastery criterion on all sets.

Charles had the opportunity to respond to as many words as possible during this phase. A 15-s see/say timing was conducted in which the researcher asked him to say the words on the flash cards as fast as he could. The procedures for Charles were the same as the experimental participants in this phase. Once the timing was complete, general praise and a small tangible reinforcer (i.e., sticker) was given for participation.

Social Validity

Once retention data for all participants had been collected, social validity was assessed for the teacher. A rating scale that was adapted from the Intervention Rating Profile-15 was created and given to the teachers in order to assess social validity (Martens, Witt, Elliot, & Darveaux, 1985). The questionnaire was designed to measure whether or not the study was perceived as producing socially significant outcomes. The questionnaire included items rated on a 6-point Likert-type scale ranging from 1 (strongly disagree) to 6 (strongly agree). This questionnaire can be found in appendix F.

CHAPTER THREE:

RESULTS

All figures in the results are displayed on the Standard Celeration Chart with the calendar days represented on the x-axis and correct answers per min on the y-axis. The chart is arranged in a semi-log fashion in order to show proportional behavior change. The slope or trend of the data is depicted by a line referred to as the “celeration line” and the term “celeration” is used to refer to the speed at which learning occurs. A divide celeration or “deceleration” refers to a decrease in frequency for that behavior over time.

Baseline

Correct responding during baseline for all three experimental participants remained stable at 0 correct words per min with high frequencies in errors. Errors ranged from 16 words per min to 48 words per min. Each participant showed an increasing trend in errors during baseline. Charles, the control participant, remained stable at 0 correct words per min with high frequencies in errors for three of the four sets of sight words. Charles correctly responded to one word (i.e., frequency of four correct words per min) twice during baseline for the 15 correct words per min set of sight words, but obtained 0% accuracy on the last baseline data point. Three baseline data points were obtained for Charles with correct responding ranging from 0-4 correct words per min and incorrect responding ranging from 24-36 incorrect words per min.

All participants remained at baseline levels (i.e., 0 correct words per min) for the control set of sight words throughout the entire study. Incorrect responding ranged from 20 words per min to 76 words per min.

Teaching

Scarlett

Table 3 displays the results of Scarlett learning sight words for each fluency aim. The table displays (1) each mastery criterion (2) the number of calendar days required to meet mastery criterion (3) the number of trials required to meet mastery criterion (4) celeration (i.e., rate of learning) for corrects and errors and (5) ending frequencies for correct words per min.

Table 3

Teaching Results for Scarlett

Frequency Target	Calendar Days	Trials	Celeration		Ending Frequency
			Corrects	Errors	
25%	17	9	X3.42	÷1.54	20 words/min
50%	28	14	X1.89	÷1.70	48 words/min
100%	39	21	X1.57	÷1.38	60 words/min

Training for 25% fluency aim lasted 17 calendar days with nine trials within those days. The celeration (i.e., rate of learning) value for corrects for Scarlett reaching the 15 correct words per min criteria was a X3.42 celeration, which demonstrates rapid learning (Kubina & Yurich, 2012). She had a decrease in errors at a ÷1.54 celeration. The teaching phase ended for Scarlett

when she reached 20 correct words per min. She ended the teaching phase with 62% accuracy in reading words. Data indicated that she consistently responded to two out of four words in the set at the end of the teaching phase for 25% fluency.

Training for 50% fluency aim lasted 28 calendar days with 14 trials within those days. The celeration value for corrects for Scarlett reaching the 30 correct words per min criterion was a $X1.89$ celeration, which represents an exceptional learning speed (Kubina, 2012). She had a decrease in errors at a $\div 1.29$ celeration. The teaching phase ended for Scarlett when she reached 48 correct words per min. She ended the teaching phase with 100% accuracy in reading words. Data indicated that she consistently responded to all four words in the set at the end of the teaching phase for 50% fluency.

Training for 100% fluency lasted 39 calendar days with 21 trials within those days. The celeration value for corrects reaching the 60 correct words per min criteria was $X1.57$ celeration, which is a moderate learning speed (Kubina, 2012). Scarlett showed a decrease in errors at a $\div 1.38$ celeration. The teaching phase ended for Scarlett when she reached 60 correct words per min on two consecutive days. She ended the teaching phase with 100% accuracy in reading words. Data indicated that she consistently responded to all four words in the set at the end of the teaching phase for 100% fluency.

Rhett

Table 4 displays the results of Rhett learning sight words for each fluency aim. The table displays (1) each fluency aim (2) the number of calendar days required to meet mastery criterion (3) the number of trials required to meet mastery criterion (4) celeration for corrects and errors and (5) ending frequencies for correct responding.

Table 4

Teaching Results for Rhett

Frequency Target	Calendar Days	Trials	Celeration		Ending Frequency
			Corrects	Errors	
25%	10	7	X3.58	÷2.04	16 words/min
50%	34	20	X1.94	÷1.70	40 words/min
100%	51	33	X1.48	÷1.42	60 words/min

Training for the 25% fluency aim lasted ten calendar days with seven trials within those days. The celeration value for corrects for Rhett reaching the 15 correct words per min criteria was a X3.58 celeration, with a decrease in errors at a ÷2.04 celeration. The teaching phase ended for Rhett when he reached 16 correct words per min on two consecutive days. He ended the teaching phase with 57% accuracy in reading words. Data indicated that he consistently responded to two out of four words in the set at the end of the teaching phase for 25% fluency.

Training for 50% fluency aim lasted 34 calendar days with 20 trials within those days. The celeration value for corrects for Rhett reaching the 30 correct words per min criteria was a X1.94 celeration, with decrease in errors at a ÷1.70 celeration. The teaching phase ended for Rhett when he reached 40 correct words per min. He ended the teaching phase with 100% accuracy in reading words. Data indicated that he consistently responded to all four words in the set at the end of the teaching phase for 50% fluency.

Training for 100% fluency aim lasted 51 calendar days with 33 trials within those days. The celeration value of corrects for Rhett reaching the 60 correct words per min criteria was a X1.48 celeration, with decrease in errors at a ÷1.42 celeration. The teaching phase ended for

Rhett when he reached 60 correct words per min on two consecutive days. He ended the teaching phase with 100% accuracy in reading words. Data indicated that he consistently responded to all four words in the set at the end of the teaching phase for 100% fluency. Rhett's celerations were rapid, exceptional, and moderate for the 25%, 50%, and 100% frequencies respectively.

Frank

Table 5 displays the results of Frank learning sight words for each fluency aim. The table displays (1) each fluency aim (2) the number of calendar days required to meet mastery criterion (3) the number of trials required to meet mastery criterion (4) celeration for corrects and errors and (5) ending frequencies of correct responding.

Table 5

Teaching Results for Frank

Frequency Target	Calendar Days	Number of Trials	Celeration		Ending Frequency
			Corrects	Errors	
25%	36	21	X1.56	÷1.14	20 words/min
50%	35	20	X1.59	÷1.25	32 words/min
100%	43	26	X1.41	÷1.37	60 words/min

Training for 25% fluency aim lasted 36 calendar days with 21 trials within those days. It took Frank more than twice as long to reach mastery of this set of sight words when compared to the other two participants. The celeration value of corrects for Frank reaching the 15 correct words per min criteria was a X1.56 celeration, with decrease in errors at a ÷1.14 celeration. The teaching phase ended for Frank when he reached 20 correct words per min on two consecutive days. He ended the teaching phase with 56% accuracy in reading words. Data indicated that he

consistently responded to two out of four words in the set at the end of the teaching phase for 25% fluency.

Training for 50% fluency aim lasted 35 calendar days with 20 trials within those days. The celeration value for corrects for Frank reaching the 30 correct words per min criteria was a X1.59 celeration, with decrease in errors at a $\div 1.25$ celeration. The teaching phase ended for Frank when he reached 32 correct words per min. He ended the teaching phase with 80% accuracy in reading words. Data indicated that he consistently responded to all four words in the set at the end of the teaching phase for 50% fluency.

Training for 100% fluency aim lasted 43 calendar days with 26 trials within those days. The celeration value for corrects for Frank reaching the 30 correct words per min criteria was a X1.41 celeration, with decrease in errors at a $\div 1.37$ celeration. The teaching phase ended for Frank when he reached 60 correct words per min on two consecutive days. He ended the teaching phase with 100% accuracy in reading words. Data indicated that he consistently responded to all four words in the set at the end of the teaching phase for 100% fluency. Frank's celerations all fell within the moderate range of learning.

Charles (Yoked)

Table 6 displays the results of Charles learning sight words to each fluency aim. The table displays (1) each fluency aim (2) the number of calendar days required to meet mastery criterion (3) the number of trials required to meet mastery criterion (4) celeration values for corrects and errors and (5) ending frequencies of correct responding.

Table 6

Teaching Results for Charles (Yoked)

Frequency Target	Calendar Days	Trials	Celeration		Ending Frequency
			Corrects	Errors	
25%	39	21	÷1.03	X1.04	12 words/min
50%	36	30	X1.72	÷1.25	37 words/min
100%	46	26	X1.37	÷1.12	48 words/min

Training for 25% fluency aim lasted 39 calendar days with 21 trials within those days. Charles did not reach the mastery criterion for 25% fluency aim. He had an ending frequency of 12 correct words per min with 33% accuracy in responding.

Training for 50% fluency aim lasted 36 calendar days with 30 trials within those days. Charles did reach the mastery criterion for 50% fluency aim. He had an ending frequency of 37 correct words per min with 80% accuracy in responding. His celeration was comparable to Scarlett's and Frank's.

Training for 100% fluency aim lasted 46 calendar days with 26 trials within those days. Charles did not reach the mastery criterion for 100% fluency aim. He had an ending frequency of 48 correct words per min with 80% accuracy in responding.

Retention

25% Retention

All experimental participants remained above the 15 correct words per min criterion during the retention check 2 weeks after reaching criterion but results were varied at the 6 weeks

retention check with only one participant demonstrating retention. Table 7 shows results of retention for 25% fluency for all participants. The table displays (1) each participant (2) ending frequencies of correct responding during the teaching phase (3) 2 week and 6 weeks retention frequencies of correct responding and (4) celeration value of the ending frequency and the 6 weeks retention check.

Table 7

Retention Results for 25% Fluency

Participant	Ending Frequency (words/min)	Two Week Retention (words/min)	Six Week Retention (words/min)	Celeration Value
Scarlett	20	24	4	$\div 1.35$
Rhett	16	16	16	X1.00
Frank	20	16	8	$\div 1.16$
Charles	12	2	16	X1.12

At the 2-week retention check, Scarlett had the highest frequency of 24 correct words per min, which was a slight increase in the frequency she achieved at the end of teaching. Rhett and Frank showed little decay in retention continuing to read the sight words at 16 correct words per min, achieving the 25% frequency aim. Scarlett had 60% accuracy and data indicated she correctly responded to one word in the set. Rhett had 50% accuracy and data indicated he correctly responded to two words in the set. Frank had 33% accuracy and data indicated he correctly responded to one of the words in the set. Charles did not meet fluency criterion for 25% fluency aim ending the teaching phase with a frequency of 12 correct responses per min, and he

did not maintain frequencies of correct responding after 2 weeks with retention data of two correct responses per min.

Figure 2 shows Rhett remained above the 15 correct words per min criterion during the retention check 6 weeks after reaching criterion, with $\times 1.0$ celeration indicating virtually no change. Figures 1 and 3 show Scarlett and Frank dropped below the criterion, with decelerations of $\div 1.35$ and $\div 1.16$ respectively. Scarlett dropped to four correct words per min and Frank dropped to eight correct words per min. Rhett had the greatest accuracy with 44% accuracy and data indicated that he correctly responded to two of the four words, the same as he achieved during teaching. Frank had 25% accuracy, which indicated he correctly responded to one word compared to two during teaching. Scarlett had the lowest accuracy with 10% accuracy and data indicated she correctly responded to one word as compared to two during teaching. As seen in figure 4, Charles' data showed better retention in correct responding after 6 weeks compared to 2 weeks. After 6 weeks, Charles' frequency was above the 25% fluency criterion despite not reaching mastery criterion during teaching. Charles had 40% accuracy in correct responding at 16 correct words per min, slightly higher than at the end of the teaching phase, and a celeration of $\times 1.12$. He correctly responded to three out of four words inconsistently.

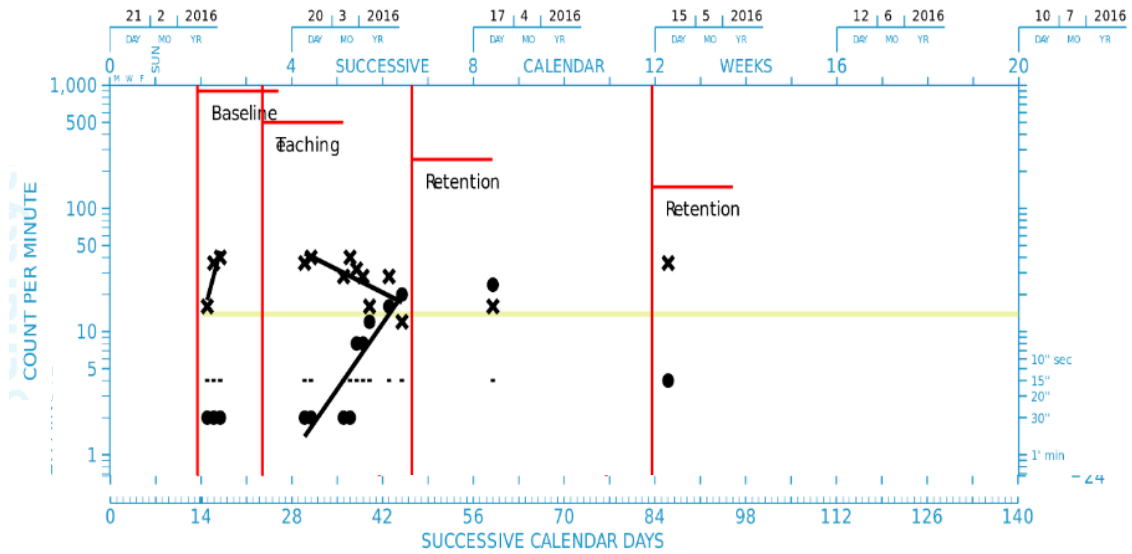


Figure 1: Scarlett 25% fluency data

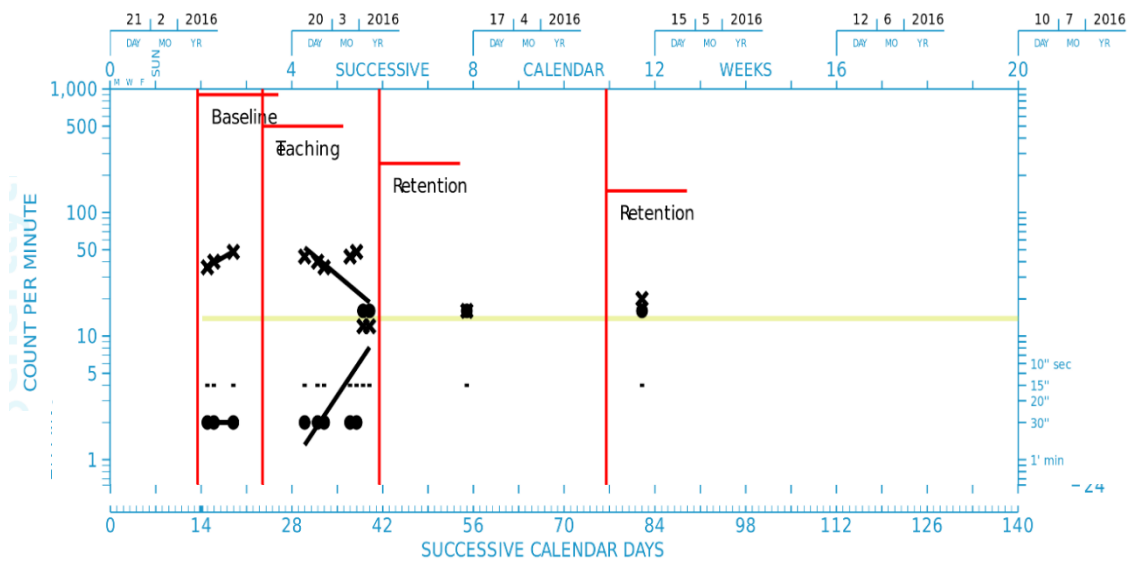


Figure 2: Rhett 25% fluency data

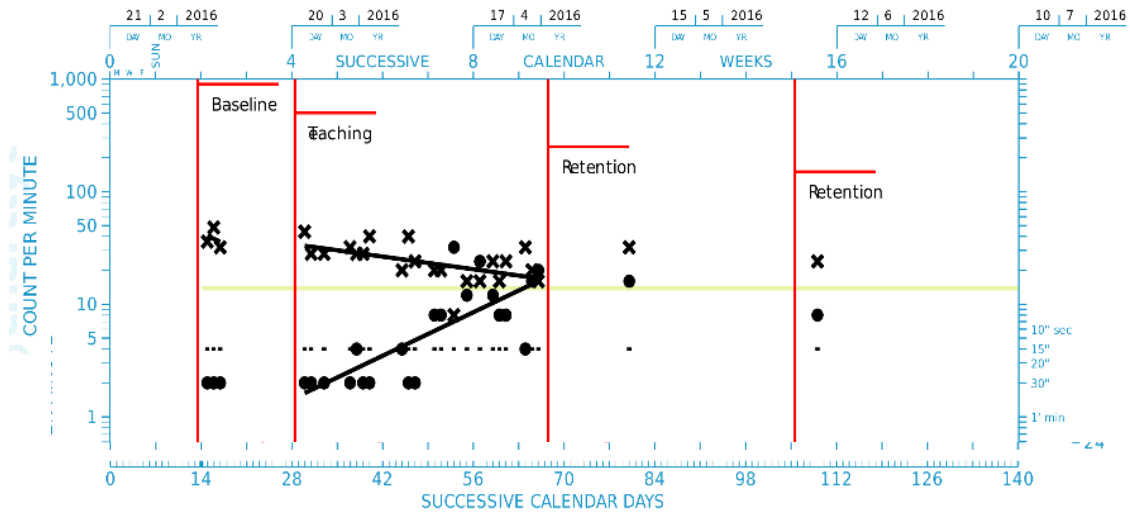


Figure 3: Frank 25% fluency data

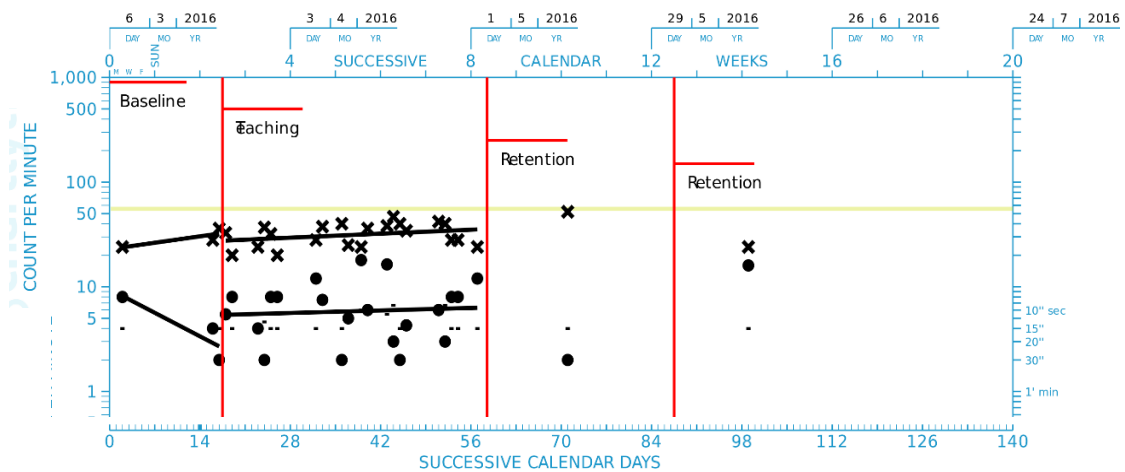


Figure 4: Charles (yoked) 25% fluency data

50% Retention

Table 8 shows results of retention for 50% fluency for all participants. The table displays (1) each participant (2) ending frequencies of correct responding during the teaching phase (3) two week and six week retention frequencies of correct responding and (4) celeration value of the ending frequency and the six week retention check.

Table 8

Retention Results for 50% Fluency

Participant	Ending Frequency (words/min)	Two Week Retention (words/min)	Six Week Retention (words/min)	Celeration Value
Scarlett	48	24	28	$\div 1.08$
Rhett	40	32	28	$\div 1.06$
Frank	32	20	24	$\div 1.03$
Charles	37	20	4	$\div 1.42$

Figure 6 shows Rhett remained above the 30 correct words per min criterion during the retention check 2 weeks after reaching criterion, while Figures 5 and 7 show Scarlett and Frank dropped slightly below the criterion. Scarlett dropped to 24 correct words per min as shown in Figure 5, and Frank dropped to 20 correct words per min as shown in Figure 7. Rhett had the greatest accuracy at 89% and correctly responded to two of the four words. Scarlett had 60% accuracy and correctly responded to three of the four words. Frank had the lowest accuracy at 33% and correctly responded to two words. Charles did not maintain teaching frequencies above 30 correct words per min in the retention check after 2 weeks, despite meeting criterion during training. Charles dropped to 20 correct words per min with 62% accuracy in responding.

Scarlett and Rhett remained around the 30 correct words per min criterion during the retention check 6 weeks after reaching criterion with 28 correct words per min, while Frank dropped slightly below the criterion to 24 correct words per min. Scarlett, Rhett, and Frank showed small deterioration in frequencies with deceleration values of $\div 1.08$, $\div 1.06$, and $\div 1.03$ respectively. Scarlett had the greatest accuracy after 6 weeks with 70% accuracy and correctly responded to three of the four words compared to four of four words during the teaching phase. Frank had 67% accuracy and correctly responded to two words, compared to four during the

teaching phase. Rhett had the lowest accuracy with 64% accuracy and correctly but inconsistently responded to all four words. Charles dropped to four correct words per min 6 weeks after teaching with 25% accuracy in responding, a deceleration of 1.4.

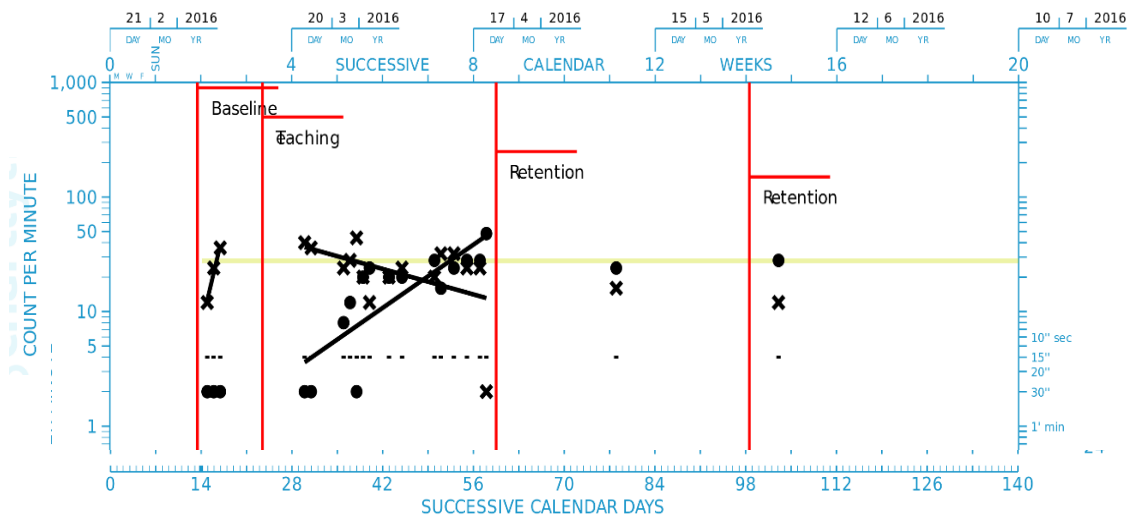


Figure 5: Scarlett 50% fluency data

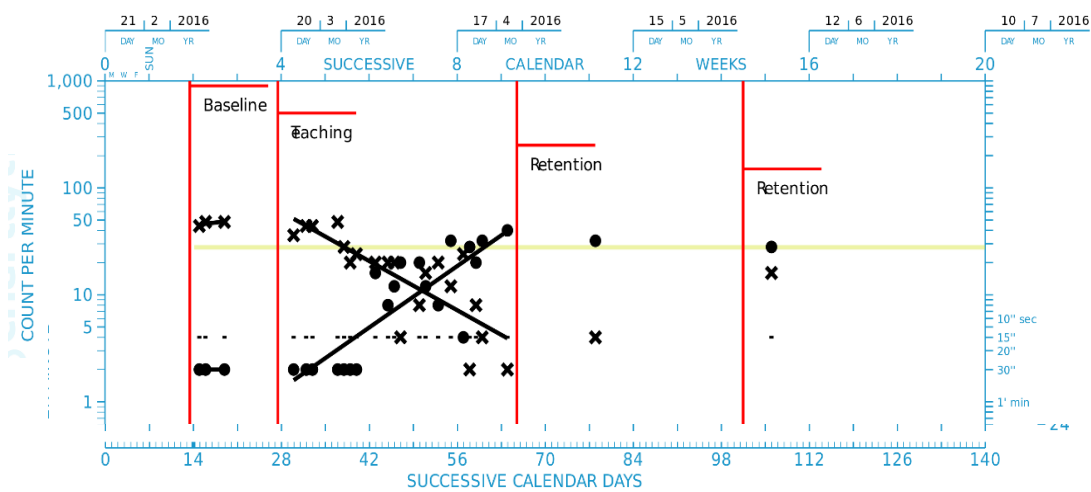


Figure 6: Rhett 50% fluency data

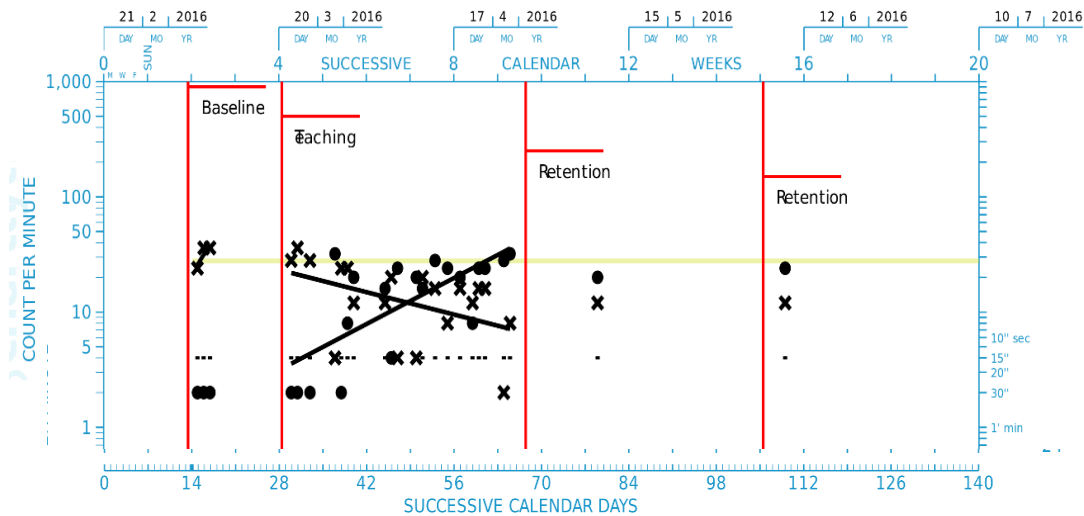


Figure 7: Frank 50% fluency data

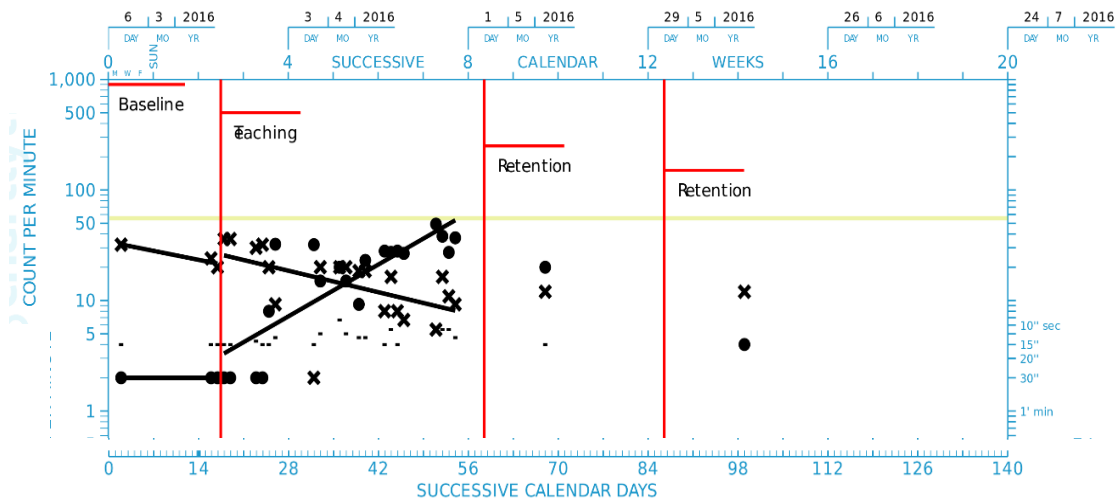


Figure 8: Charles (yoked) 50% fluency data

100% Retention

All three experimental participants dropped below the 60 correct words per min criterion during the retention check 2 weeks after reaching criterion. Table 9 shows results of retention for 100% fluency for all participants. The table displays (1) each participant (2) ending frequencies of correct responding during the teaching phase (3) two week and six week retention frequencies

of correct responding and (4) celeration value of the ending frequency and the six week retention check.

Table 9

Retention Results for 100% Fluency

Participant	Ending Frequency (words/min)	Two Week Retention (words/min)	Six Week Retention (words/min)	Celeration Value
Scarlett	60	48	28	$\div 1.16$
Rhett	60	56	48	$\div 1.04$
Frank	60	56	24	$\div 1.20$
Charles	48	48	20	$\div 1.16$

Figure 11 shows Frank had the smallest decay in frequency of correct responding with 56 correct words per min and 100% accurate responding. Figure 9 shows Scarlett had the largest decay in responding dropping from 60 correct words per min to 48 correct words per min with 100% accurate responding. Figure 10 shows Rhett dropped from 60 correct words per min to 52 correct words per min with 100% accurate responding. Data indicated that all participants continued to consistently and correctly respond to all four words in the set after 2 weeks. Figure 12 shows Charles remained below the 60 correct words per min criterion 2 weeks after the teaching phase with correct responding of 48 correct words per min.

Scarlett and Frank dropped well below the 60 correct words per min criterion during the retention check 6 weeks after reaching criterion responding at 28 correct words per min with a celeration of $\div 1.16$ and 24 correct words per min with a celeration of $\div 1.20$ respectively. Data for Rhett's retention check 6 weeks after obtaining mastery have not been collected to date. Scarlett had the greatest decay in accuracy after 6 weeks with 58% accuracy and data indicated that she correctly responded to two of the four words compared to the four out of four words she

correctly responded to in the teaching phase. Frank had 67% accuracy and data indicated he correctly responded to two words compared to the four out of four words he correctly responded to in the teaching phase. Data for six week retention check for Charles have not been collected to date.

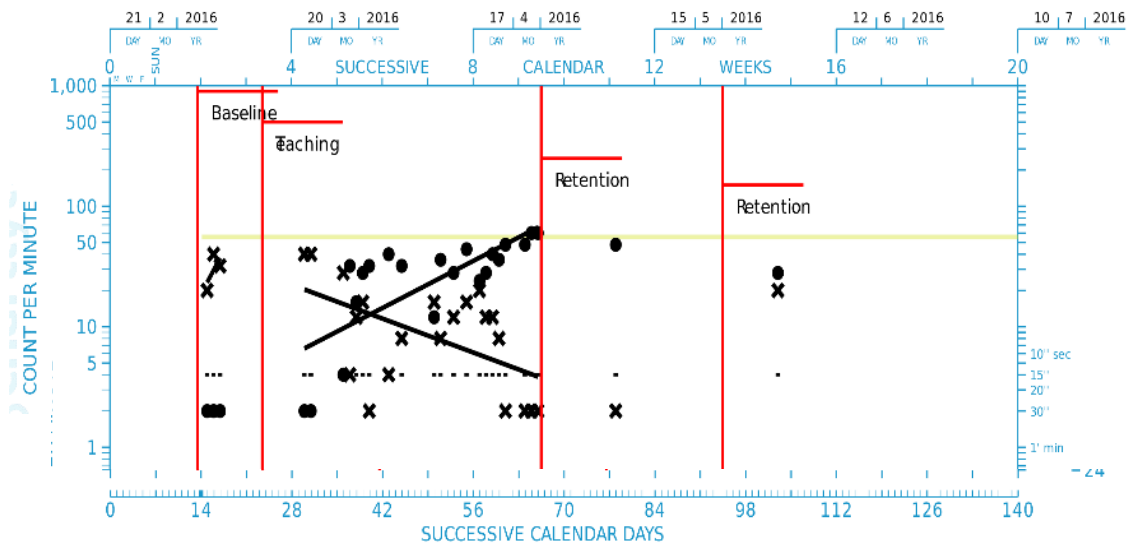


Figure 9: Scarlett 100% fluency data

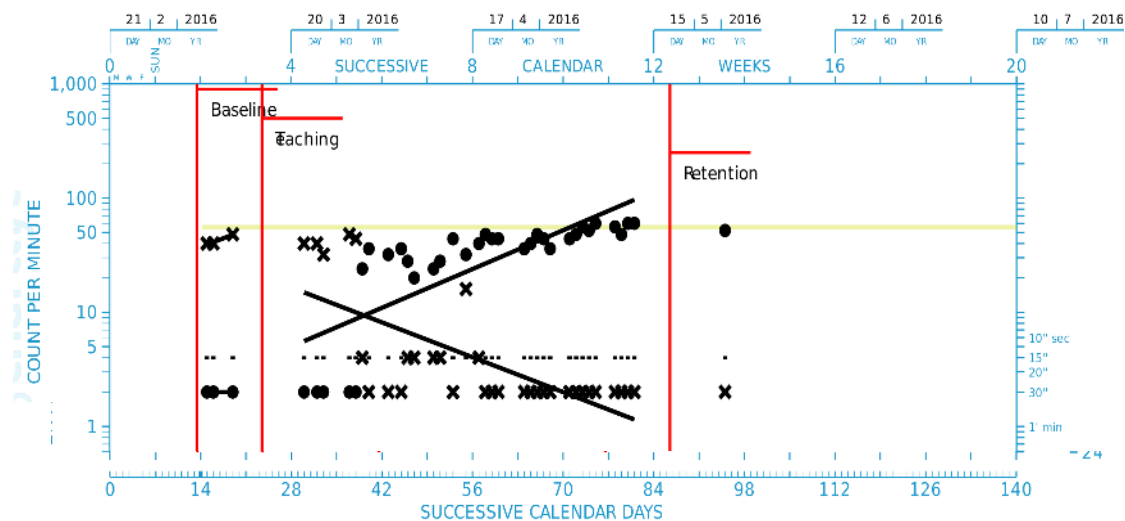


Figure 10: Rhett 100% fluency data

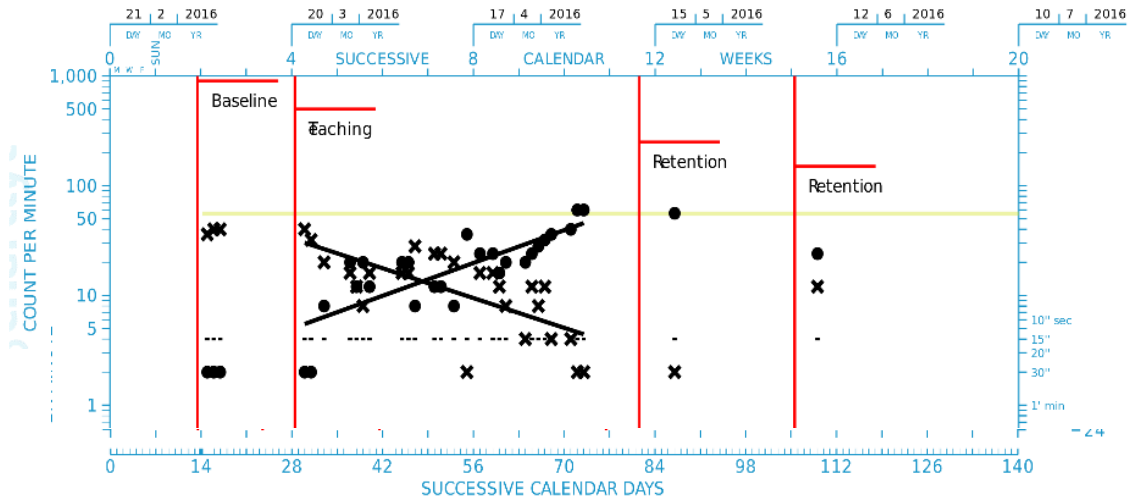


Figure 11: Frank 100% fluency data

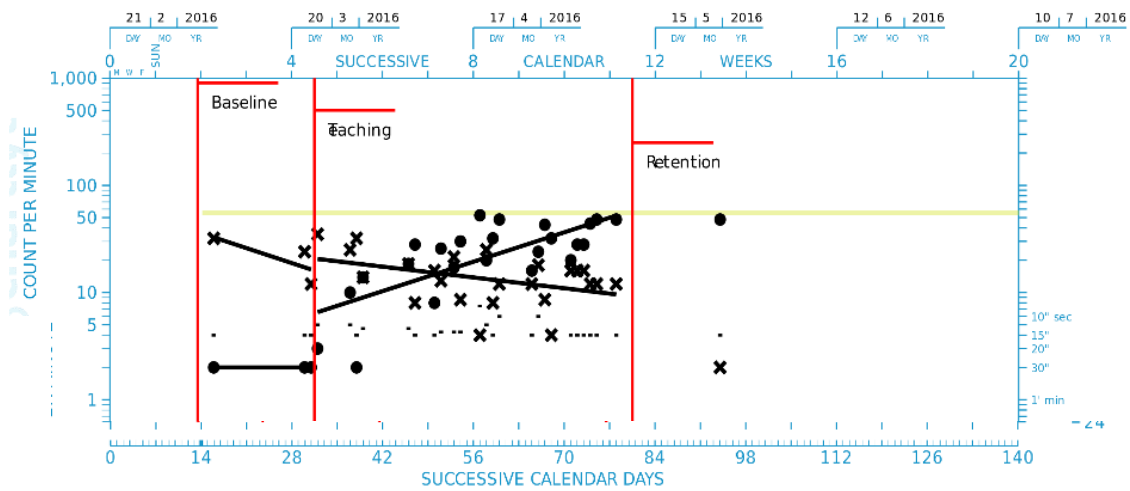


Figure 12: Charles (yoked) 100% fluency data

Social Validity

The social validity questionnaire for the teacher participant in the study was administered on the last day of data collection via pen and paper. The average score on the 6-point Likert-type scale ranging from 1 (strongly disagree) to 6 (strongly agree) was 6, showing that the teacher

thought the study was socially valid. The teacher reported that the study targeted an important goal and the intervention was appropriate for the children's academic level. She also reported that the intervention seemed to be beneficial for the students.

CHAPTER FOUR:

DISCUSSION

The purpose of the present study was to examine the differential effects of retention on reading sight words once the skill had been strengthened to three frequencies using fluency training and the precision teaching (PT) method. The study addressed issues related to previous research on retention while extending the research by evaluating the effect frequencies below the predicted frequency aim had on retention. Sight words were taught to 15 correct words per min (i.e., 25% of the predicted fluency aim), 30 correct words per min (i.e., 50% of the predicted fluency aim), and 60 correct words per min (i.e., 100% of the predicted fluency aim).

All participants maintained teaching frequencies of correct responding 2 weeks after reaching mastery for all three frequency aims. Frequencies of incorrect responding also remained at or near those attained during the teaching phase. These findings are consistent with results from previous research. Kubina et al. (2008) found that after building a skill to just below the predicted frequency aim and just above the predicted frequency aim, frequencies of correct responding maintained 2 weeks after reaching mastery criterion. Results show that even at low frequency aims students can still retain information 2 weeks after teaching.

Six weeks after teaching, retention results began to vary across the participants and the three frequencies. Retention at the 25% fluency aim was the most varied and unpredictable. Scarlett and Frank failed to maintain correct responding at 15 correct words per min, indicating a

lack of retention. Only Rhett maintained his frequency of correct responding, however, his errors also increased. In addition, all participants showed higher frequencies of incorrect responding compared to correct responding. Celeration values ranged from $X1.12$ for the control participant to $\div 1.35$ for experimental participant Scarlett.

Six-week retention data for the 50% fluency aim indicated retention for all three participants. All participants maintained frequencies of around 30 correct words per min. Incorrect responding during the retention probes were consistent with teaching phase levels of responding. Overall, retention data for the 50% fluency aim showed consistent maintenance of teaching phase data. These data are not consistent with previous research. Results of Berens et al. (2003) suggested that practicing a skill at response frequencies below the fluency aim did not produce skill retention one month after training; however, data from this study show that building word recognition skills to 50% of the predicted fluency aim under specific conditions will produce retention 6 weeks after training. Celeration values were similar across experimental participants, ranging from $\div 1.03$ to $\div 1.08$. Only the control participant's celebration value of $\div 1.42$ showed a lack of retention after 6 weeks.

Six-week retention data for the 100% fluency aim showed decay in retention of correct responding and an increase in incorrect responses. Retention data showed that learning a skill to the predicted frequency aim of 100% does not necessarily produce greater retention than learning a skill to 50% of the predicted frequency aim 6 weeks after training. This outcome is unexpected and inconsistent with previous literature on retention. For example, Berens et al. (2003) found that participants produced greater retention when emitting response frequencies close to the predicted fluency aim during training. In addition, practitioners presume that if students meet the 100% predicted frequency aim, retention will follow. However, these data indicated this is not

the case. The reason for the differences in these data compared to other studies is not clear. Because the words sets were counterbalanced and the participants were given different sets at each frequency aim, we know that the words were not a factor. Words learned at the 50% frequency were not easier than words learned at the 100% frequency. Further research and replication is needed to examine these outcomes compared to those in other studies.

A possible reason for the overall decay in retention at the 100% fluency aim may be provided by data in Kubina et al. (2008). Participants in Kubina et al. (2008) all demonstrated previous knowledge of reading by beginning the study at different frequencies. Although participants demonstrated similar levels of decay across the two aims tested by Kubina et al. (2008), the participant who began at the lowest frequency had the largest decay in retention at 6 weeks. Kubina et al. (2008) results are consistent with the results of this study in that the participants performed well on retention checks following 2 weeks, but there was more decay in retention 6 weeks after training. By controlling for prior knowledge, this study was able to eliminate that confounding variable.

Additional findings are important for discussion. First, the experimental participants learned and retained more words as the fluency aim increased. Specifically, participants correctly responded to two words at the end of the teaching phase for 25% fluency aim and recalled 1-2 words during the retention probes. For the 50% fluency aim, participants correctly responded to 2-3 words during both the teaching and the two retention periods. All participants correctly responded to all four of the words at the end of the teaching phase for the 100% fluency aim, correctly responded to all four words during the 2-week retention check, and during the 6-week retention check, participants responded correctly to 2-4 words.

Second, based on a limitation in the Kubina et al. (2008) study, this study controlled for practice opportunities with a yoked participant. Charles had the same number of trials, the same number of words, and was given the same amount of reinforcement as Frank across all three frequencies. However, his teaching and retention data were different than Frank. Despite having the same amount of exposure and training as Frank, Charles only met mastery criterion for the 50% fluency aim but failed to demonstrate retention. His retention data for the other two aims were variable, showing an increase in frequency at the 25% fluency aim but a decrease in frequency at the 100% fluency aim.

Third, all participants remained at baseline levels for the control set of sight words throughout the course of the study. These words were used to control for carryover effects between the sets of words. Data showed that participants did not learn the words in this set based on exposure to the other words. In order to eliminate exposure of words outside of the study, information given to parents and teachers about the study only described the study as using sight words and did not elaborate on what words in particular would be used during the study.

Limitations

Certain limitations were present during the course of the study. One limitation is that this study was a single case design. With only three participants, data are not generalizable. Additionally, the data in this study only reflect sight words and are not representative of other skill sets. More data need to be collected on a variety of participants and skills in order to generalize data sets.

Another limitation of the study is that each set of sight words only had four different words. With that being said, it became clear that participants could meet the fluency criterion by

correctly responding to 1 or 2 of the four words and move on to the next phase of the study. Only having four words in each set meant that participants had more opportunities to respond to the words they knew and could quickly say “I don’t know” to the words they did not know. Flash cards were shuffled to maintain random exposure to the words; however, depending on the order of the words, participants could have four out of ten flash cards be the same word during a timing. A greater number of words may address this limitation but would also extend the time needed to teach the words.

Additionally, participants were moved to the next phase of the study based on frequencies of correct responding regardless of incorrect responding. Increasing accuracy could affect the extent of retention. More research on frequencies below the predicted frequency aim is needed to identify whether or not this is a typical outcome.

Another limitation is that participants were only required to remain at mastery criterion for two sessions. Previous research has suggested that the amount of practice at high frequencies produce greater retention (Berens et al., 2003). Participants in this study were only required to remain at mastery for two days and most participants did not spend more than a few sessions at or around the frequency aim. It is possible that more practice around the aim could produce greater retention.

Lastly, there were a few variables creating limitations with the individual participants. While in the retention phase of the study, Scarlett left the school for the summer and her retention data points were collected in the home setting. However, her data appear consistent with the other participants suggesting it is unlikely that collecting data in the home setting made an impact on her responding.

Frank and Charles began diverting their eyes to other objects in the room and moving around in the seat during the teaching phase timings. These behaviors could have had an impact on the skill acquisition and accuracy during the teaching and retention phases for these participants. If the participant was not attending to the task, the data could have been unrepresentative of what words the participant actually knew.

Future Directions

This study lays the foundation for future research on retention at different frequency levels. However, more data need to be collected using additional participants, across different populations, and different skills such as reading, math, spelling, etc. Retention could be different based on the population of the individual and the measured skill. Further research in these areas would increase generalization.

Additional research should address the limitation of the study regarding the number of words in each set. Being exposed to more and a greater variety of words could affect the accuracy and skill acquisition. This study only allowed participants to emit four different responses. In the clinical setting, individuals are given the opportunity to emit more than four different responses during a 15-s timing which decreases the probability of the individual meeting mastery criterion of a skill before learning all of the words.

Further, additional research could incorporate accuracy into the mastery criterion when making the decision to move to the retention phase. The data in this study suggest that accuracy in learning could affect the accuracy in retention 2 and 6 weeks later. Other research could compare the accuracy mastery criterion to the fluency mastery criterion using the three frequencies in order to determine which mastery produces the greatest amount of retention, or

whether attention must be paid to both. Fluency has been proven to be the best method for producing retention at 100% of the predicted frequency aim, but future research could look at the effect of accuracy on retention at the different frequency aims.

This study required the participants to perform the skill at aim for two sessions, but future research should have individuals spend more time performing the skill around the frequency aim. Decay in retention at the 100% fluency aim during this study suggest that participants did not reach fluency after performing the skill at high frequencies for two days. Rather, the results show that performing the skill with 100% accuracy and 100% fluency aim for two days can produce decay in retention after 6 weeks.

Lastly, future research should look at the acquisition of the skill after the retention period. In other words, how many sessions would an individual require in order to return to the fluency criterion? Data could show that individuals return to fluency aim more quickly with one frequency as opposed to another.

Kubina et al. (2008) found little difference in retention decay for two different frequency aims suggesting that lower frequency aims could also produce retention. Using much lower frequency aims than studied by Kubina and colleagues, this study found that although lower frequencies can produce retention 2 weeks after teaching, retention begins to decay 6 weeks after teaching. Results of this study show there can be retention at lower frequency aims. Additionally, this study found that performing a skill at 100% predicted fluency aim may not always produce retention. These data challenge the fluency literature which says that mastery is met once reaching a fluency aim. In clinical practice, an individual is assumed to have mastered a skill once reaching the predicted fluency aim. These data show these skills may not be retained despite reaching the mastery criteria.

As discussed, if students do not retain the skill, they do not truly master the skill. It is important to continue this line of research in order to develop the evidence that will allow practitioners to more effectively and efficiently work with students so they may truly master skills. Although fluency is identified as a more sensitive measure of mastery (e.g., Berens et al., 2003), this study showed that more work is needed to understand the parameters of predicated fluency aims and the manner in which outcomes, including retention, are most efficiently established.

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APPENDICES

Appendix A: Letter Worksheet

m	v	a	f	y
s	w	e	q	j
h	u	d	c	l
t	p	b	n	r
z	l	g	o	k
x				

Appendix B: Sight Word Worksheet

again	put	know	could
give	any	once	over
by	from	her	of
live	some	when	every
were	think	an	old
thank	then	open	

Appendix C: Interobserver Agreement

Interobserver Agreement for Baseline and Teaching Conditions

Participant: _____ Condition: _____ Date: _____

Assessor: _____ Video: _____

See/Say			Hear+See/Say (Teaching Only)		
Timing #	Corrects	Errors	Timing #	Corrects	Errors
1			1		
2			2		

Notes:

Appendix D: Procedural Integrity Baseline

Procedural Integrity Form: Baseline

Participant

Date

Video

Research Assistant

Component	Integrity	
Participants are given for see/say timing	Yes	No
Card is presented	Yes	No
Timer is started after the participant emits first sound	Yes	No
Words are shown one at a time	Yes	No
When the timing ends, praise is given for participation	Yes	No

Appendix E: Procedural Integrity Teaching

Date	Research Assistant		
Component	Integrity		
Participants are given instructions for the see/say timing	Yes	No	N/A
Timer is started when participant emits first sound	Yes	No	N/A
Card is presented one at a time	Yes	No	N/A
When the timing ends, no praise or reinforcement is given for correct answers or high frequencies	Yes	No	N/A
Flash cards are shuffled	Yes	No	N/A
Directions are given for the hear+see/say timing	Yes	No	N/A
Card is presented one at a time	Yes	No	N/A
Timer is started when participant emits first sound	Yes	No	N/A
When the timing ends, praise or reinforcement is given for correct answers and high frequencies prior to error correction	Yes	No	N/A
Flash cards are shuffled	Yes	No	N/A
Directions are given for the hear+see/say timing	Yes	No	N/A
Timer is started when participant emits first sound	Yes	No	N/A
Card is presented one at a time	Yes	No	N/A
When the timing ends, praise or reinforcement is given for correct answers and high frequencies prior to error correction	Yes	No	N/A
Flash cards are shuffled	Yes	No	N/A
Directions are given for the see/say timing	Yes	No	N/A
Timer is started when participant emits first sound	Yes	No	N/A
Card is presented one at a time	Yes	No	N/A
When the timing ends, no praise or reinforcement is given for correct answers or high frequencies	Yes	No	N/A
Total Yes		/15	

Appendix F: Social Validity

Social Validity Questionnaire

Teacher _____

Participant _____

Date _____

The purpose of this questionnaire is to understand your views on the on the appropriateness and acceptability of the project. Please circle the number which best describes your agreement or disagreement with each statement.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
My participation (e.g., nominating students) was reasonable and uncomplicated	1	2	3	4	5	6
I clearly understood the goal and procedures.	1	2	3	4	5	6
The intervention targets an important goal	1	2	3	4	5	6
The intervention is appropriate for the child's academic level	1	2	3	4	5	6
The intervention did not interrupt the student's daily class routine or disrupt the schedule	1	2	3	4	5	6
The procedures used in this project were acceptable	1	2	3	4	5	6
Participation in this project was worthwhile.	1	2	3	4	5	6
The intervention seemed to be beneficial for the student	1	2	3	4	5	6

Appendix G: IRB Approval Letter



RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813) 974-7091

October 27, 2015

Bethany Greene
ABA-Applied Behavior Analysis
Tampa, FL 33614

RE: **Expedited Approval for Initial Review**
IRB#: Pro00023773
Title: Evaluating the Effects of Different Frequencies on Retention

Study Approval Period: 10/27/2015 to 10/27/2016

Dear Ms. Greene:

On 10/27/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
[Protocol V1_10.19.15-1.docx](#)

Note, no research activities can begin without submitting the required letter of support and receiving an approval through the Amendment process

Consent/Assent Document(s)*:
[Parental Consent V1_10.19.15.docx.pdf](#)
[Teacher Consent V1_10.19.15.docx.pdf](#)

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s).

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review

research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

[Study involves children and falls under 45 CFR 46.404: Research not involving more than minimal risk.]

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

A handwritten signature in black ink, appearing to read 'Kristen Salomon', followed by a horizontal line.

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board